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ABSTRACT

Several studies have shown an improvement in the performance of motor skills following imagined performance of the skill, or "mental practice." One unresolved issue has centered on whether the effect being observed is in fact a practice effect. As one alternative, the effect may be a simple instance of planning when to use a skill, or deciding in advance what strategy to select. Alternatively, the possibility has been noted that mental practice may have its effects by influencing motivational factors, and not by exercising some component of the skill. A report is given of an experiment in which the procedures used by G. Nigro in 1983 to study imagined practice were replicated. The Nigro study reported that attempts to manipulate motivation make no difference in the effectiveness of imagined practice on dart throwing, whereas the content of the practice does. The results of that study appeared to eliminate motivation accounts and simultaneously to begin a specification of the relevant content of mental practice. A description is given of the experiment, designed both to replicate and extend Nigro's findings, and to examine the role of self-reported imagery ability using Nigro's procedure, a procedure that is apparently free of the confounding effects of motivation. (JD)

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DOES IMAGINED PRACTICE HELP IN LEARNING A MOTOR SKILL?

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We generally assume that we must perform a skill to learn that skill. According to Aristotle, "He who is learning the harp, learns the harp by harping." However, during the last forty years several studies have shown an improvement in the performance of motor skills following imagined performance of the skill, or "mental practice." In addition, mental rehearsal techniques are becoming enormously popular among athletes as a means of enhancing performance (Silva, 1983; Suinn, 1984). Aside from its application in physical education, therapy and rehabilitation, the mental practice phenomenon has important implications for our understanding of motor learning and control, and of the nature of skill and its development (Meichenbaum, 1977; Neisser, 1984; Singer and Switzer, 1980).

One unresolved issue has centered on whether the effect we are observing is in fact a practice effect. As one alternative, the effect may be a simple instance of planning when to use a skill, or of deciding in advance what motor options to select (i.e. choosing a strategy). However, this seems unlikely given the relatively non-strategic tasks in which mental practice benefits have often been documented. Alternatively, Richardson (1967a; 1967b) and Corbin (1972) have both noted the possibility that mental practice may have its effects by influencing motivational factors, and not by exercising some component of the skill. Mental practice might simply increase subjects' interest in the task, or lessen their anxiety.

Several of the more recent studies of mental practice have attempted to address this issue, but one study addresses the motivation issue quite directly. Nigro (1983) reports that attempts to manipulate motivation make

no difference in the effectiveness of imagined practice on dart throwing, whereas the content of the practice does. She manipulated expectations of success and failure by having subjects imagine successful or unsuccessful performances. In addition, subjects mentally rehearsed the dart throwing from either of two points of view: imagining themselves as observers viewing their own practice from the side, or as performers of the imagined practice. The results showed no effects of the motivational manipulation, but a significant effect of the "visual vantage point."

These results, therefore, seem to eliminate motivation accounts and simultaneously to begin a specification of the relevant content of mental practice. Given their potential significance, a replication seems very important.

Our study also examined a second issue, the role of differential imagery ability. Since mental practice is often assumed to require the use of imagery (e.g. Ryan and Simons, 1981, 1982; Silva, 1983; Singer and Switzer, 1980), some researchers have suggested that the subjects' imagery ability should play a role in its effectiveness. Attempts to assess this relationship have met with mixed results.

The current experiments were thus designed both to replicate and extend Nigro's findings, and to examine the role of self-reported imagery ability using Nigro's procedure, a procedure apparently free of the confounding effects of motivation.

In the first experiment, two of the five conditions reported by Nigro (1983), a mental practice group and a control group, were run in a procedure closely matched to hers. Twenty-six volunteers participated in individual

sessions and were assigned alternately to either the experimental (mental practice) or the control group. The experimenter first administered the imagery scales - the VVIQ (Marks, 1973) and the kinesthetic subscale of Betts QMI (from Richardson, 1969). The remainder of the procedure was divided into five blocks. In each of Blocks 1, 3 and 5 all subjects threw twenty-four darts. During Blocks 2 and 4, the control subjects were given a five-minute break which they spent playing a computer game. During Blocks 2 and 4, the experimental group performed their mental practice.

Instructions for the mental practice were read to the experimental group at the beginning of the second block. These instructions were, with minor changes, identical to those used by Nigro. Subjects were then asked to sit at a desk from which they could not see the target or the throwing line and to imagine throwing twenty-four darts, counting each throw out loud. During Block 4, they were asked to sit in the same place and to imagine another twenty-four throws.

Performance on the actual throws was measured by distance in centimeters from the center of the Bull's Eye. The Block 1 scores for both groups were comparable. An analysis of variance shows that subjects improved, but improved equally in both conditions. Therefore our results fail to replicate Nigro's.

Given this negative outcome, it is not too surprising that improvement in the task was uncorrelated with either of our imagery measures. For both groups, neither imagery scale was predictive of gain, with all correlations well below significance levels. The imagery scores do confirm that the two groups were comparable with regard to their imagery ability.

It is important to note that, in Nigro's data, only the mental practice

subjects improved; her control group, unlike ours, showed no difference in performance from the first to the last block of throws. Perhaps our baseline (Block 1) dart throws provided too much actual practice for both groups, overshadowing whatever additional effects mental practice might provide. For this reason, Experiment 2 eliminated the first block of throws. In addition, to maximize the likelihood of mental-practice effects, two blocks of mental practice were given prior to the first block of actual throws. Then a third block of mental practice was given, followed by a last block of actual throws.

Twenty-four subjects were recruited, and were assigned alternately to either the mental practice or the control group. Subjects were given the VVIQ and the kinesthetic scale of the QMI. The remainder of the experiment was divided into five blocks. All subjects threw darts during Blocks 3 and 5. During Blocks 1 and 2, the mental practice subjects imagined throwing twenty-four darts after receiving the same instructions employed in Experiment 1. Between these blocks, they were given a five-minute break during which they played the computer game used in Experiment 1. For the corresponding blocks of the procedure, the control subjects participated in a different task, involving the observation of moving shapes on a computer screen. (The control task was in fact generating pilot data for a completely different study being run in our laboratory.) During Block 4, the mental practice subjects rehearsed another 24 throws mentally; the control group received a five-minute break.

An analysis of variance on subjects' performance finds neither a difference between Conditions nor an effect of practice. There was no interaction between the two factors.

Once again, VVIQ and the kinesthetic scale scores from the QMI were comparable for the two groups. Neither imagery measure correlated with performance, with all correlations below significance.

In short, reducing the amount of actual practice obtained by both experimental and control subjects did not affect the critical result, namely the absence of a mental practice effect.

Despite the use of Nigro's procedure in our first experiment and a close variant of it in the second, we have twice failed to observe a mental practice effect. One possible cause for this failure is that throwing skills in our subjects were simply too well practiced, too near ceiling levels, leaving little room for improvement. To eliminate this possibility, subjects in the final experiment were asked to throw with their non-dominant hand in order to make the task more novel.

As we noted earlier, our data contrast with Nigro's not in the mental practice group (which appears to improve in both designs), but in the control group (which improves in our data but not in Nigro's). At the same time, the regard in which our procedures depart most from Nigro's is in the task performed by the control subjects while the experimental subjects are doing mental practice. While Nigro's subjects did a Stroop color-word task (Stroop, 1935), our subjects in Experiment 1 played an entertaining computer game and in Experiment 2 performed a perceptual task judged by most subjects to be somewhat challenging and interesting. On the surface at least, this difference seems unlikely to matter. Nonetheless, the final experiment includes two control groups: one engaged in playing the computer game

employed in Experiment 1 and the other in the Stroop task employed by Nigro. Thus there are three groups in this experiment: a mental practice group; a control group given the computer game during the appropriate phases of the procedure; and a second control group given the Stroop task during the corresponding phases of the procedure.

Twelve subjects were recruited in the same manner as in Experiment 2. The procedure was the same as that followed in Experiment 1 with the following changes. First, subjects were asked to throw with their less-preferred hand. Second, one control group spent five minutes doing the Stroop task during blocks 2 and 4, instead of playing the computer game.

As in Experiment 1, all groups were matched with respect to their initial skill. An analysis of variance shows, as in Experiment 1, an overall practice effect. There is no main effect for Condition, but there is a significant interaction between Block and Condition. This interaction reflects the fact that, while all three groups are initially indistinguishable statistically, the Stroop Task group fails to improve as much the other two groups. These latter conditions do not differ from each other.

In this experiment, we finally observe an effect attributable to practice conditions, but not the effect expected on the basis of prior research. Reliable differences are obtained between the mental practice group and the second control group; however, an equally robust effect is observed in comparing the two control groups. Engaging in mental rehearsal or playing a computer game are equally beneficial for dart-throwing performance, whereas performing a Stroop task somehow disrupts later dart throwing.

Said differently, we have at last replicated Nigro's result, but obviously in a context which causes concern about what this result means.

The results of these experiments can be summarized briefly. In the first place, no improvement in performance attributable directly to mental practice is observed in any of the three experiments. While mental practice subjects did increase their dart-throwing accuracy, they did so no more than control subjects, with the exception of our Stroop-task controls in Experiment 3. Subjects in that group did not improve; if anything, their performance got worse. Said simply: our results suggest that mental practice and some control procedures are neutral with regard to subsequent performance. Other control procedures seem to interfere with subsequent performance. Therefore, by choosing one control group or another, one can make a "mental practice benefit" appear or vanish.

Second, across procedures, mental rehearsal was no more effective for subjects with vivid visual or kinesthetic imagery. Correlations between imagery scores and improvement measures were nonsignificant for all groups of subjects. While others in the literature have reported correlations between mental rehearsal benefits and imagery vividness (e.g. White, Ashton and Lewis, 1979), we are inclined to argue, as we did at the outset, that these results are ambiguous. As noted, it is possible that these results are mediated by motivational factors.

Taken together, these experiments form a consistent picture, but one which differs critically from earlier studies demonstrating a mental practice effect in dart throwing (e.g. Nigro, 1983; Vandell, Davis and Clugston, 1943). At a minimum, we are entitled to conclude that the choice of control group is of considerable importance. Simply keeping the control group

occupied in something to prevent mental rehearsal is inadequate. In our experiments, control subjects engaged in interesting and challenging activities did not differ from the mental practice subjects in their subsequent performance. When the control task employed is one requiring concentration and effort but which is essentially uninteresting, the mental practice group shows an advantage.

Why should the choice of a control group be so critical? One possibility is that the mental practice effect is in fact a motivational one, as a number of authors have suggested, and not a case of actual learning. Perhaps the control subjects doing the Stroop interference task became bored or fatigued while the other controls remained interested. As another possibility, we know from the literature on consolidation (Baddeley, 1976) that the effects of learning become more enduring with the passage of time, and that some activities can disrupt this consolidation process. It is conceivable that mental practice is a neutral activity, not disrupting consolidation, but that more obnoxious activities (such as some control tasks) do cause interference. This conjecture is consistent with the finding that mental practice effects are more readily observed if there is an initial period of actual performance, giving the subject something to consolidate.

These speculations can easily account for another of Nigro's findings (the finding which in fact recommended Nigro's procedure so highly to us at the outset). Nigro's results indicate that the content of mental practice matters, so that subjects who mentally rehearsed dart throwing from the visual vantage point of the thrower improve considerably more than those imagining the practice from the viewpoint of an observer, sitting on the sidelines, watching themselves. Nigro reports that this second condition, in

addition to being less effective, was also more difficult for her subjects. Six of her 36 "observer" subjects reported difficulties in following the instructions for this condition, and indicated, when debriefed, that they had in fact employed the other vantage point in their imagined practice some or most of the time. In this way, her results do not necessarily contradict our own. Our claim is that more difficult or more frustrating activities will diminish mental practice benefits. Hence, on our view, it was the difficulty of the imagined content which was influential in Nigro's procedure, and not the imagined content per se.

One obvious factor has not been addressed in this study, namely the degree to which the practiced task requires strategy or planning. A number of authors suggest that mental rehearsal is more effective with tasks requiring a more obvious cognitive component such as sequencing or strategy (Corbin, 1972; Feltz and Landers, 1983; Minas, 1978, 1980; Wrisberg and Ragsdale, 1979). When the skill involves these components, it is hardly surprising that mentally reviewing them would help. At a minimum, there would be less to think about during the activity itself, thus leaving more attention free to concentrate on the details of the physical skill being performed.

The possibility of strategic planning, together with motivation effects and the sharpening of attention, argue that there certainly are substantial gains to be had from imagined performance of skilled action. Mental rehearsal is a routine part of training for many athletes and of some therapies, and there is good reason to believe in its efficacy. What is at issue here is not the efficacy per se, but the effectiveness of mental practice for improvement of a subtler kind - improvement internal to the

activity itself.

Clearly this presupposes a distinction which is not easy to make (although there are clear cases), a distinction between the planning or preparation of an action, and its execution. We would argue that this distinction can be addressed empirically. In particular, if mental practice turns out to be interchangeable with actual performance, this would argue against separating the "cognitive" or "planful" from the "motoric" aspects of skill, and would argue instead that cognitive influences are critical at all levels of the control hierarchy. In contrast, if clear limits to mental practice can be defined, this would speak to the boundary between these two aspects of skill and motor control.

Within this context we are suggesting both the considerable importance of understanding mental practice effects, and the unpersuasiveness of extant data. In particular, imagined performance certainly leads to mental preparation for action, at both motivational and strategic levels. There are some procedures in the literature which remove these influences, yet still show positive results, suggesting a mental practice effect, not just mental preparation. The present findings, however, suggest that it may not be the experimental condition in these studies which is beneficial, compared to a neutral control group, but a neutral experimental group, compared to a somehow-interfering control procedure. Thus our results provide reason for serious skepticism about published data; if mental practice effects do exist, this remains to be persuasively demonstrated.

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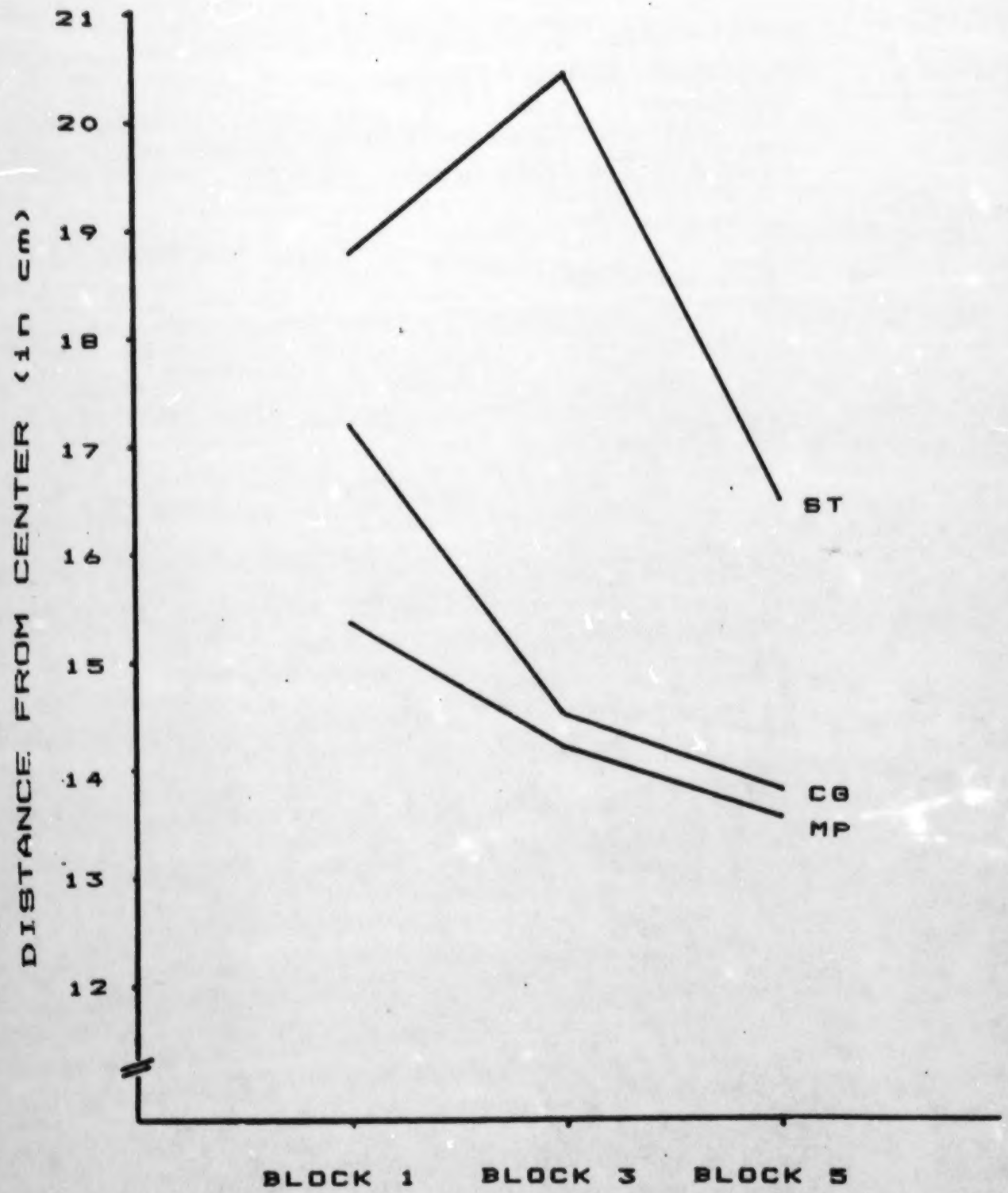
FIGURE CAPTION

Figure 1. Summary of results, Experiment III. MP indicates the mental practice group; CG indicates the control group engaged in the computer game; ST indicates the control group which did the Stroop task. See text for details.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